

RECLAMATION

Managing Water in the West

Design Workshop Final Report

Imperial National Wildlife Refuge Imperial Native Fish Habitat Reconstruction

Conducted in Cooperation with the Fish and Wildlife Service for
Bureau of Reclamation, Lower Colorado Region.



**U.S. Department of the Interior
Bureau of Reclamation
Lower Colorado Region
Boulder City, NV**



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Introduction

The features known as the Ducks Unlimited (DU2) Ponds were initially constructed as part of the implementation of the 1997 Biological Opinion¹, which required the Bureau of Reclamation (Reclamation) to construct or restore a minimum of 300 acres of protected habitats for native fish within the floodplain of the Lower Colorado River (LCR).

All tasks related to site construction were completed in autumn of 2002. The site was treated with the piscicide, rotenone to eliminate all non-native fish species in October and December of 2002, and initially stocked with about 658 fingerling razorback suckers (*Xyrauchen texanus*) in March 2003. Despite multiple rotenone treatments, warmouth sunfish (*Lepomis gulosus*) were positively identified in small numbers.

During the spring and summer of 2003 the introduced population of razorback suckers declined to an estimated 25, while the population of non-native warmouth increased to an estimated 17,000. While the reasons for the decline of the razorback sucker population may never be known, two factors were identified: (1) hypoxia (inadequate levels of dissolved oxygen), and (2) the persistence of the non-native warmouth sunfish.

Investigation into the probable causes of the hypoxia pointed towards deficiencies related to the site design, and issues with compatibility with the adjacent farm field units. The most important factors are listed below:

- The current design includes only one point for fresh water input, and one point for drainage. This does not allow for adequate water quality maintenance, nor does it allow for adequate isolation of the ponds if and when the system is invaded by non-native fish.
- The ponds cannot be maintained at the intended water surface elevation, due to a hydrologic connection between the ponds and the adjacent farm fields. If the ponds are filled, as designed, the adjacent fields would be inundated, which could kill any trees or plants in the fields. Because the water surface levels of the ponds are being maintained at a significantly lower elevation, aquatic vegetation is able to overtake the pond and consumes high levels of dissolved oxygen when respiring at night. Furthermore, the shallow depths make the fish vulnerable to the large numbers of avian predators which are common to the area.

Too many objectives were being attempted within a limited area leading to limited success. While investigating ways to correct the existing problems, it became obvious that the possibility of creating additional marsh and backwater habitat under the LCR Multi-Species Conservation Program² (LCR MSCP) could be a component of the new design.

¹ U.S. Fish and Wildlife Service. 1997. Biological and Conference Opinion of Lower Colorado River Operations and Maintenance. USFSW, Region 2. Albuquerque, NM.

² Lower Colorado River Multi-Species Conservation Program. 2004. *Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan*. Final. December 17. (J&S 00450.00). Sacramento, CA.

A one-day meeting was held on December 1, 2004, where a panel of experts was convened to discuss the future of the DU2 ponds with an emphasis on native fish conservation. It was decided that the ponds would not be connected to the river via a semi-permeable rock structure, as is present at Beal Lake or Cibola National Wildlife Refuge's High Levee Pond. Groundwater and/or pumped river water would be the only two available options for water delivery. The group agreed that the most important problem to solve was the threat of non-native predatory fish entering the system. The panel decided to convene a workshop to develop a new design for the site. This report is the outcome of that workshop.

Workshop Objective

Establish the design criteria and develop the preferred design (and costs³) which will both improve the required habitat functions, and increase the habitat acreage of the DU2 Ponds facility.

³ The costs developed in this design are rough estimates, based on the assumptions described in the document.
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Current Description

Imperial National Wildlife Refuge (INWR) is located approximately 30 miles north of Yuma, Arizona (Figure 1). The features known as the “DU2 Ponds⁴” were developed in 2000 to provide resting/nesting area(s) for waterfowl, riparian values and as a native fish sanctuary for razorback suckers (*Xyrauchen texanus*). The site consists of 96 acres. When developed it was made up of four cells with one pond in each cell⁵. The ponds included approximately 35 acres of water ranging in size from 4 – 14 acres. The current site cells are numbered from 1-4 (north to south). The remaining land in the complex was dedicated to the development of native riparian forest, consisting of terraces surrounding the ponds which could be intentionally flooded to provide moist soil conditions for riparian-obligate birds.

The ponds were renovated in 2002 to remove non-native fishes and stocked with razorback sucker (RBS) in 2003. Non-native fish were almost immediately found in the system requiring another renovation and RBS were again stocked in Pond 1 in 2004.

However, there were other major problems encountered in maintaining fish in this pond complex besides non-native fish. These problems included high water temperatures and low oxygen concentrations in all of the ponds making the survival of the fish impossible. To ameliorate high water temperatures and low oxygen concentrations, in Pond 1, a timer was installed on the well and water was introduced between midnight and 6 a.m. during the summer when temperatures were elevated. This resulted in survival of fish in Pond 1 but had no impact in the remaining 4 ponds where fish kills occurred. As the purpose of the site was to maintain fish in all of the ponds it was decided that an effort should be initiated to correct these problems and successfully establish a native fish sanctuary where a self-sustaining, recruiting population could become established and persist through time.

The riparian component of the design was largely unsuccessful, despite, multiple plantings of cottonwood, willow, and mesquite trees in the terraced areas surrounding the ponds. High soil salinity was identified for the lack of success in establishing trees.

⁴ Named in reference to a partnership with Ducks Unlimited, INWR, and Reclamation.

⁵ Cell 2 contains two ponds which are connected, and for all practical purposes is essentially one body of water. There has been some inconsistency between the terms “ponds” and “cells”. For simplicity, this report will refer to cell 2 as a single pond, for a total of four cells and four ponds.

Existing Cell Conditions

The existing ponds range from 4 to 14 acres with a total surface area of 35 acres. The maximum depth in any one pond is 6 feet. Layout of the ponds provides for water flow from north (near the pump) to south through the system. Each pond has a single inflow at the northern end flowing to a single outflow at the southern end. The outlets gravity-driven, and are submerged approximately 3 feet, with the water flowing through a tower with stop logs that controls the amount of water leaving the pond. Each inlet tower includes a wire screen to prevent the entrance/egress of fish >1 inch total length but will allow smaller fishes to enter or leave the pond at higher water levels. They are surrounded by large stands of cattails with common reed and bulrush (*Typha*, *Phragmites*, *Schoenoplectus/Scirpus*, respectively.) dispersed throughout the cattails. The bottom is a sandy-silt substrate and during the spring and summer an overabundance of a variety of submerged macrophytes (*Najas*, *Myriophyllum*, and *Potamogeton*) dominates the open water. Approximately 50 acres of land were originally dedicated to native riparian forest, but the area is currently dominated by a mix of salt cedar, mesquite, and willows (*Tamarix*, *Prosopis*, and *Salix*, respectively) with several areas being devoid of vegetation (Figure 2).

Figure 1. Location Map

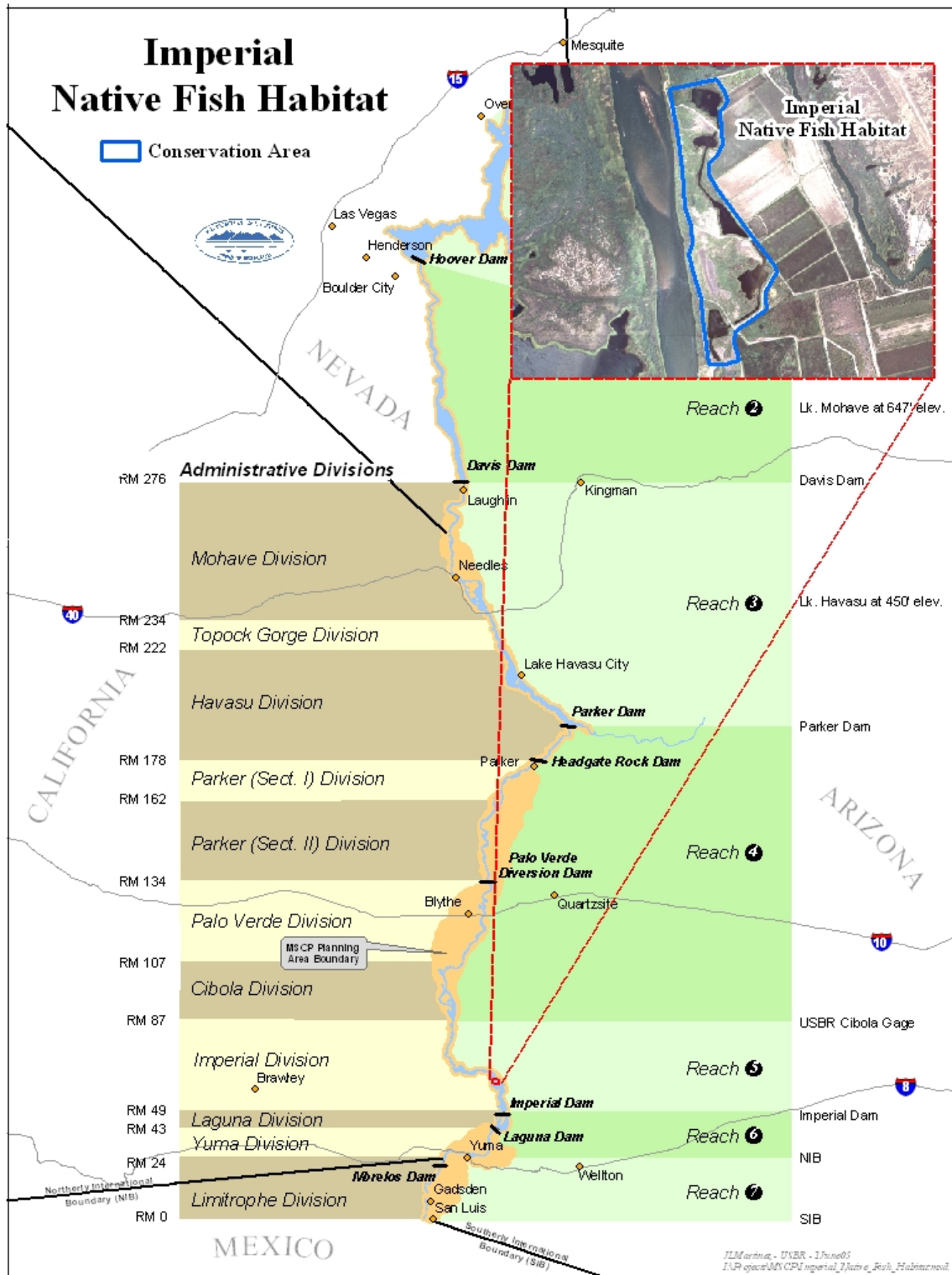


Figure 2. Aerial View of Existing Cells



Design Goals

The initial step taken by the team during the workshop was to clarify goals for the design. In a highly interactive session the following four goals were clarified and prioritized. They served as guidance for the workshop during development of the design.

Highest Priority for Design:

Reconstruct existing ponds to create backwaters that contain the physical, chemical, and biological conditions required to support native lower Colorado River fishes in a healthy condition.

Medium Priority for Design:

Expand (within the 96 acres of the site) surface area and/or marsh habitat.

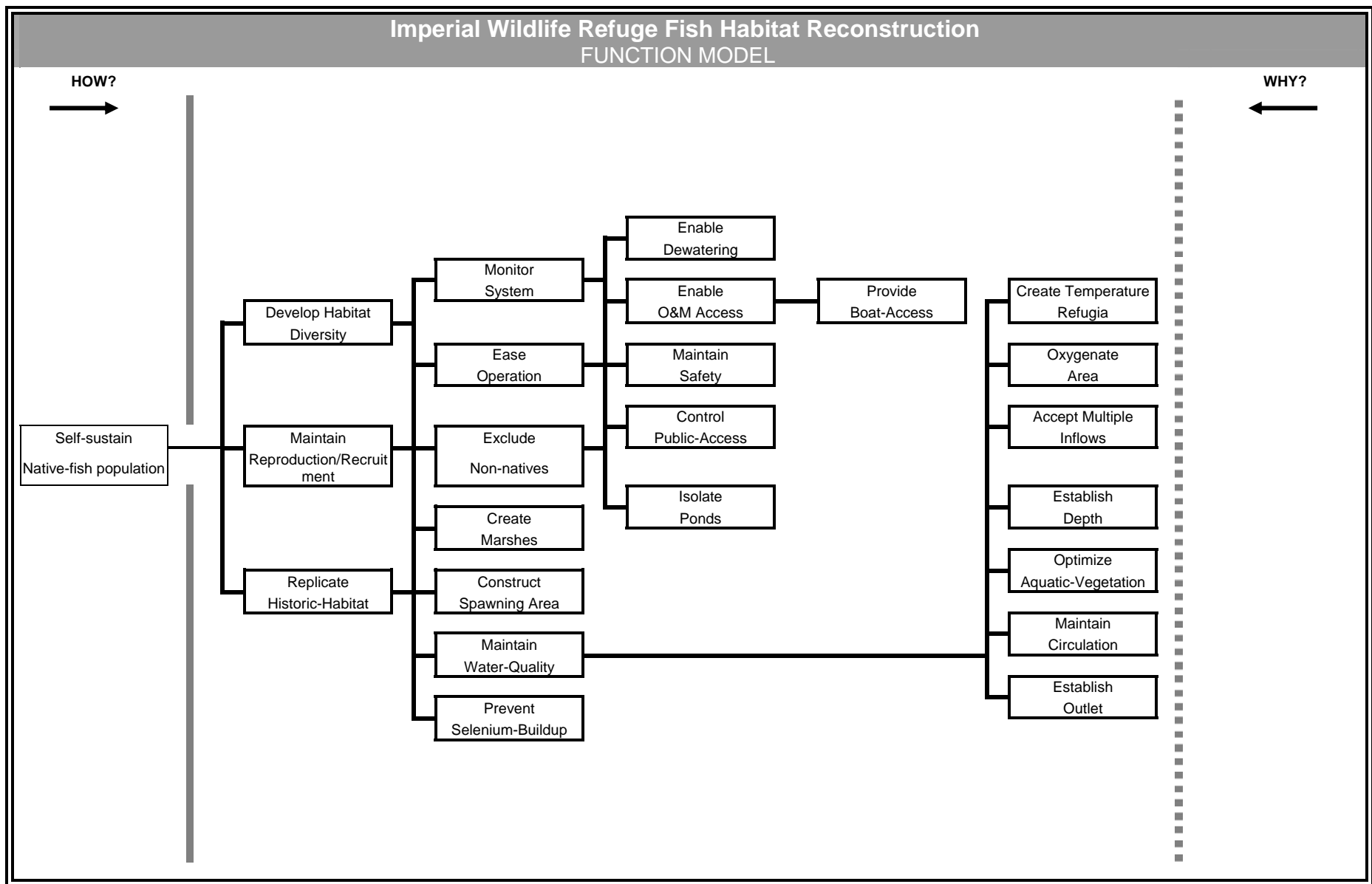
Design (easily maintainable) features with a target life of at least 50 years.

Lower Priority for Design:

Design system which will be able to increase existing knowledge of managed habitat for LCR fishes.

Function Model

The workshop participants listed the functions that would accomplish the goals outlined above. They structured these functions as shown in the model on the next page. This analysis served as a review of the overall system prior to the formal design work.



Design Features

Introduction:

Our design duplicates many of the physical properties of Cibola High Levee Pond⁶ (High Levee), while using groundwater as the source for fresh water delivery, rather than passive subsurface flow. It has been determined that there is not sufficient head gradient to provide a passive subsurface design, such as high levee. Groundwater was selected as the preferred source of fresh water at this site because of (1) the lowest probability to introducing non-native fish, eggs, and larvae, and (2) the alluvial substrate's presumed ability to act as a filter to remove selenium from Colorado River water.

The group selected the following design features to be included in the new design. This approach was based on the High Levee Pond conceptual design⁷, modified to function within the site constraints.

Size and Depth:

The new design maximizes the backwater habitat acreage within the boundaries created by the existing roads. Two additional ponds will be created, increasing the total number of ponds from four to six, which will add approximately 40-50 acres of new backwater habitat. The six ponds will range in size from approximately 9 acres to 17 acres (Figure 3).

To provide a more diverse range of habitats for native fish, each pond has a larger variety of water depths than the current ponds. The workshop attendees agreed upon the following depth ratios: 20% less than 5 ft, 60% between 5 to 10 ft, and 20% 10-12 ft (or greater) deep.

The design expands and re-contours the existing backwater habitat. This addresses both a deficiency with the existing habitat design and provides a basis for expansion of new habitat. Deeper expansion areas were placed adjacent to the existing shallow ponds to create larger and deeper ponds with a diversity of depths and contours.

⁶ High Levee is a cut-off oxbow of the lower Colorado River, located on Cibola National Wildlife Refuge. High Levee is unique, in that since 1993, it has served as the only successful sanctuary for LCR native fish, supporting all life stages of bonytail and razorback sucker.

For additional information see:

Marsh, P.C. March 15, 2000. Fish Population Status and Evaluation in the Cibola High Levee Pond, Report to U.S. Bureau of Reclamation, agreement #99-FG-30-00051. Arizona State University. Tempe, AZ.

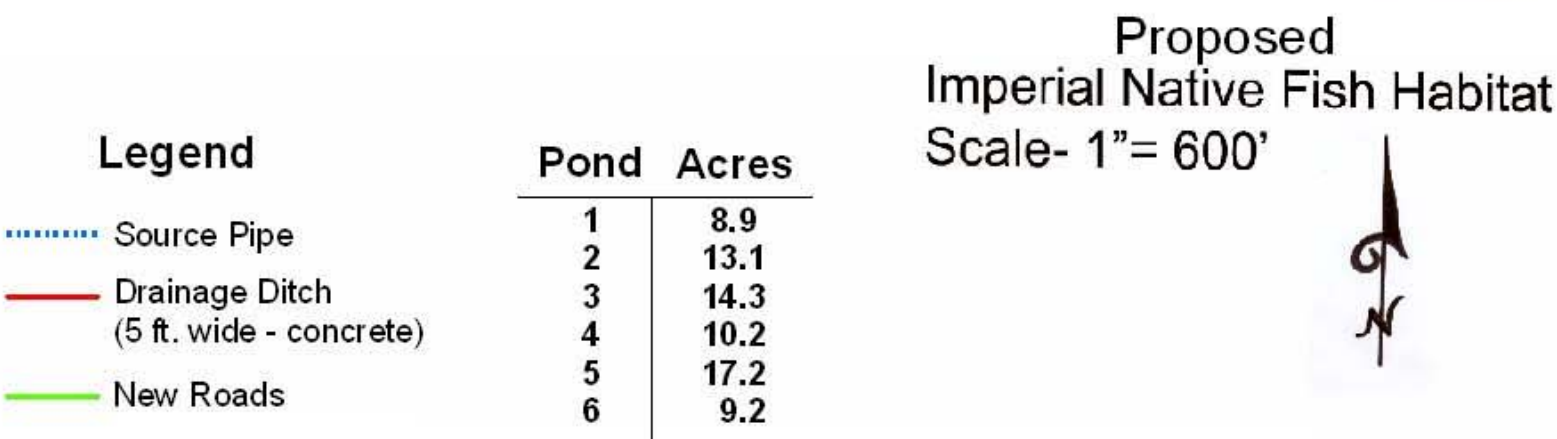
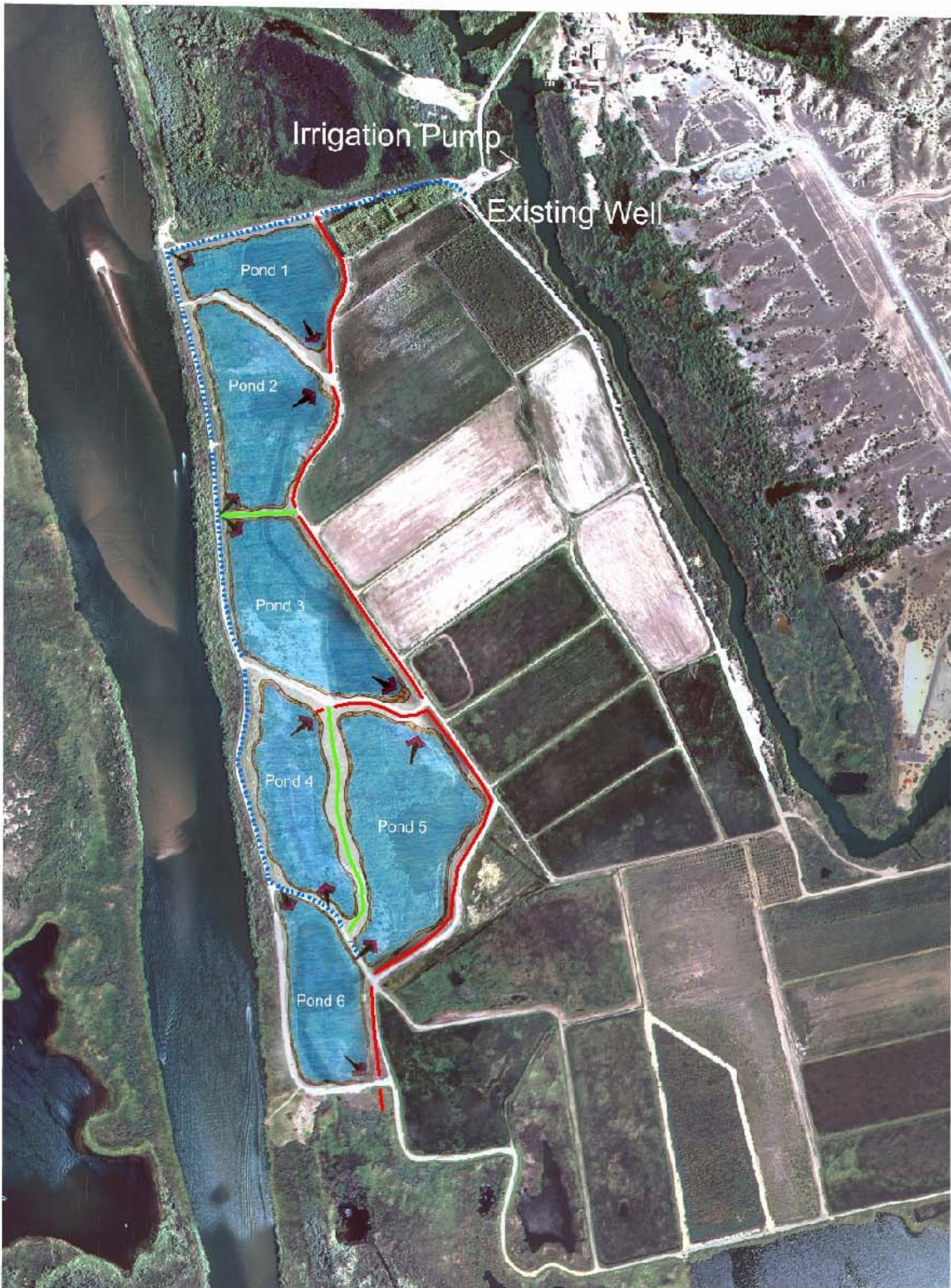
⁷ Mueller, G.A., and J. Carpenter. In Press. The known ecology of Bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*) and the potential role of oxbow habitats in their evolution, conservation and recovery. U.S. Geological Survey, Denver, Colorado.

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Design Features (Continued)

The new design increases pond depth to maximize the volume of useable habitat for fish. The design provides deeper areas for thermal refuge, to maximize survival during the summer, and provides areas of adequate depth to prevent emergent plant growth and inhibit submerged aquatic plant growth. Steeper slopes will be created along some of the pond edges to limit encroachment of emergent vegetation. Riprap, which would provide the stability for steep slopes, would provide valuable escape cover for native fish.

Figure 3. Site Layout – Plan View



The conceptual renderings in this report were prepared by Lindsay Green, U.S. Bureau of Reclamation

Design Features (Continued)

Fish Collection Kettles

The deepest pond areas will be around the outflow/drain pipes. Kettles will serve to concentrate all of the fish (when the pond is drained) into a small, manageable area, which would facilitate fish salvaging efforts. The kettle itself is small (approximately 10 ft by 10 ft) however the size will vary individually by pond. Drawing the water down to this level would also facilitate chemical treatments for non-native fish eradication by minimizing the volume of water to be treated. This would result in large cost savings during each treatment over the life of the site.

Currently, the lack of groundwater seepage would realistically allow for all of the ponds to be drained to a minimum pool. It is possible, however that by excavating deeper (as is prescribed under this design) that groundwater seepage would be higher, possibly to the extent that draining the ponds to the minimum pools is not possible.

Water Delivery Infrastructure

An additional well will be installed to provide fresh water to the larger open water area. Furthermore, this would allow for redundancy in delivering fresh water to the ponds.

The new design severs all hydrological connections between ponds. Each pond will have a separate water inlet and a water outlet. Individual ponds will have the capacity for individual water management (both filling and draining) as well as fisheries management. This will greatly reduce the potential for movement of non-native fish species between ponds. If and when the site is contaminated by non-natives, renovation of individual ponds will be simplified by isolating the ponds.

An integrated drainage system along the east side of the ponds will provide the capacity to drain them individually to prevent salt buildup, and will also divert agricultural runoff from the farm field area away from the ponds.

The drainage system will allow independence between the management of the fields and ponds. The ponds will also be protected from potentially harmful fertilizer runoff from the farm field areas, and prevent pond water from backing up into the fields.

It should be noted that there is an alternative filtered water source that could provide larger volumes of water to the system at lower operational cost. The existing irrigation pump, which pumps directly from the inlet canal to Martinez Lake, could be fitted with fish screens to allow water to be pumped to the ponds, while preventing the introduction of non-native fish, eggs, and larvae. The fish screen technology is currently being evaluated at another site. If successful, this approach would provide a more dependable source of water for the site. All alternatives will be considered at the final design stage.

Design Features (Continued)

Inflow Placement

All inflow pipes will be set in deeper water (>10 ft) to increase dissolved oxygen concentration at the greater depths (which are more prone to hypoxia) upon water delivery. A pressurized aerated injection system will be designed to both (1) maximize the circulation of inflowing water, and (2) maximize dissolved oxygen concentration. During the hot summer months, the incoming groundwater will be cooler than pond water. The lens of cooler, more oxygenated water delivered to the bottom of the ponds will provide a thermal refuge for the fish during times of stress.

Hummocks

The new design incorporates hummocks, which are planting beds for emergent vegetation. These submerged mounds will provide shallow zones to be planted with California bulrush (*Schoenoplectus californicus*). The emergent vegetation will provide shade and cover for native fish. The hummock design provides the spatial pattern of emergent vegetation and open water to encourage a diverse invertebrate community, which in turn provides a food source for native fish. This pattern also encourages insect predators which prey on mosquito larvae.

In addition to the benefits to native fish, the hummocks will provide additional habitat for a variety of marsh species. The tops of the hummocks will be set within 12 inches of the water surface for the benefit of marsh birds, including western least bittern (*Ixobrychus exilis*) and potentially Yuma clapper rail (*Rallus longirostris yumanensis*) and other species. The site design includes 18 hummocks, each of which is approximately 20-foot wide by 100-foot long, set within 12 inches of the water surface (Figure 4).

Gravel Spawning Beds

Each pond will include elongated areas either adjacent to the hummocks, or shorelines with gentle topographical relief designed to provide suitable habitat for native fish to spawn. These spawning beds will be relatively flat, lined with a plastic liner (or a similar product) to inhibit colonization by emergent vegetation, and covered with large gravel to cobble (½ inches – 3 inches) which would provide a suitable substrate for fish spawning. Depths of spawning beds will range from 2 to 6 feet deep with some being adjacent to deeper water areas.

Boat Ramps/Staging Areas

A boat ramp and staging area will be constructed at each pond. These areas will allow for access for fisheries management and site maintenance. These ramps will be appropriately sloped and covered with gravel to inhibit growth of emergent vegetation. Adjacent to these ramps will be a staging area, which will be used for setup and temporary storage of equipment including trucks, boats, pumps, etc. These ramps and staging areas will be located near the outflow structures, fish collection kettles, and the drainage system.

Design Features (Continued)

Environmental Compliance

Environmental compliance will be completed by Imperial NWR. This includes compliance with the National Environmental Policy Act, the Archaeological Resources Protection Act, Section 7 of the Endangered Species Act, and Sections 401 and 404 of the Clean Water Act. Reclamation will provide a detailed project description and additional materials as needed to facilitate environmental compliance requirements.

Figure 4. Typical Hummocks



(Henderson Demonstration Wetland, Henderson Reclamation Facility, NV. Photo courtesy of Joan Thullen, USGS)

Pond Layout - Pond 1

POND 1. LAYOUT DESCRIPTION (SEE FIGURE 5):

Water Delivery Infrastructure:

Place the inlet on the west side at the north end.
Place the outlet on the east side at the south end.

Size, Depth, and Contours:

Develop approximately 8.9 acre pond.

Develop pond contours to represent the following depths:

- A. Twenty percent <5 feet with depths located between shore and the 10-foot contour.
- B. Sixty percent between 5 and 10 feet.
- C. Twenty percent between 10 and 12 feet.
- D. Maximum depth of 12 feet.

Hummocks/Vegetation:

Develop a hummock at south end near inlet and on periphery deep area(s).

Develop area(s) <5 feet deep for emergent vegetation.

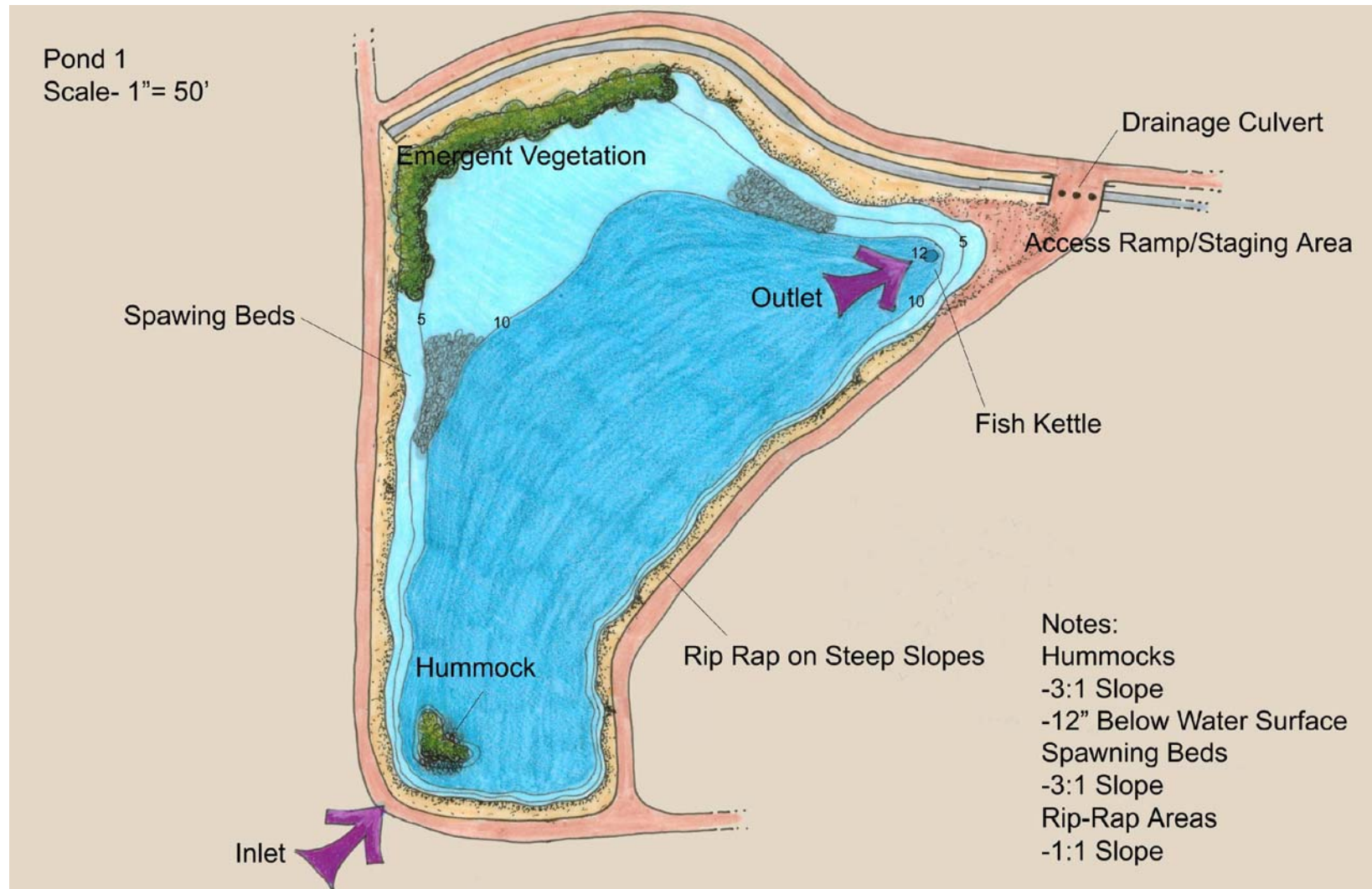
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate ranging from ½-3 in.

Boat Ramp/Staging Area:

Develop launch area(s) on south end, east side.

Figure 5. Pond 1 - Plan View



Proposed Design - Pond 2

Pond 2. LAYOUT DESCRIPTION (SEE FIGURE 6):

Water Delivery Infrastructure:

Place the inlet on the west side at the south end.
Place the outlet on the east side at the north end.

Size, Depth, and Contours:

Develop 13.1 acre pond.

Develop pond contours to represent the following depths:

- A. Twenty percent <5 feet with those depths between shore and the 10-foot contour.
- B. Sixty percent between 5 and 10 feet.
- C. Twenty percent between 10 and 12 feet.
- D. Maximum depth of 12 feet.

Hummocks/Vegetation:

Develop a hummock in the south end near inflow and on periphery deep area(s).

Develop area(s) <5 feet deep for emergent vegetation.

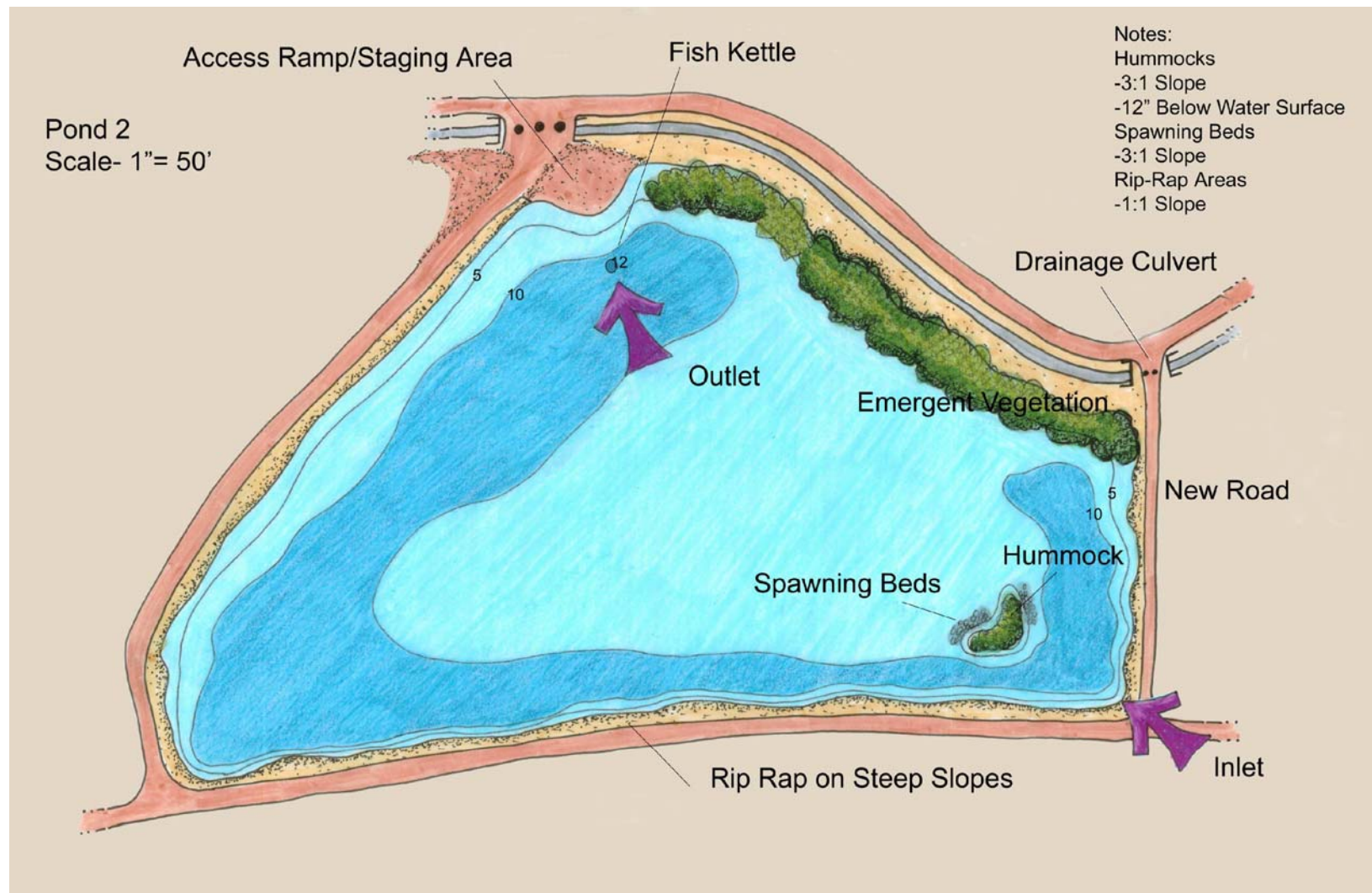
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate with substrate ranging from 1-3 inches.

Boat Ramp/Staging Area:

Develop launch area(s) on north end, east side.

Figure 6. Pond 2 - Plan View



Proposed Design - Pond 3

POND 3. LAYOUT DESCRIPTION (SEE FIGURE 7):

Water Delivery Infrastructure:

Place the inlet on the west side at the north end.
Place the outlet on the east side at the south end.

Size, Depth, and Contours:

Develop 14.3 acre pond.

Develop pond contours to represent the following depths:

- A. Twenty percent <5 feet with those depths between shore and the 10-foot contour.
- B. Sixty percent between 5 and 10 feet.
- C. Twenty percent between 10 and 12 feet.
- D. Maximum depth of 12 feet.

Hummocks/Vegetation:

Develop area(s) <5 feet deep for emergent vegetation.

Develop two hummocks, one near inlet and one near the middle of the pond in or near deep water.

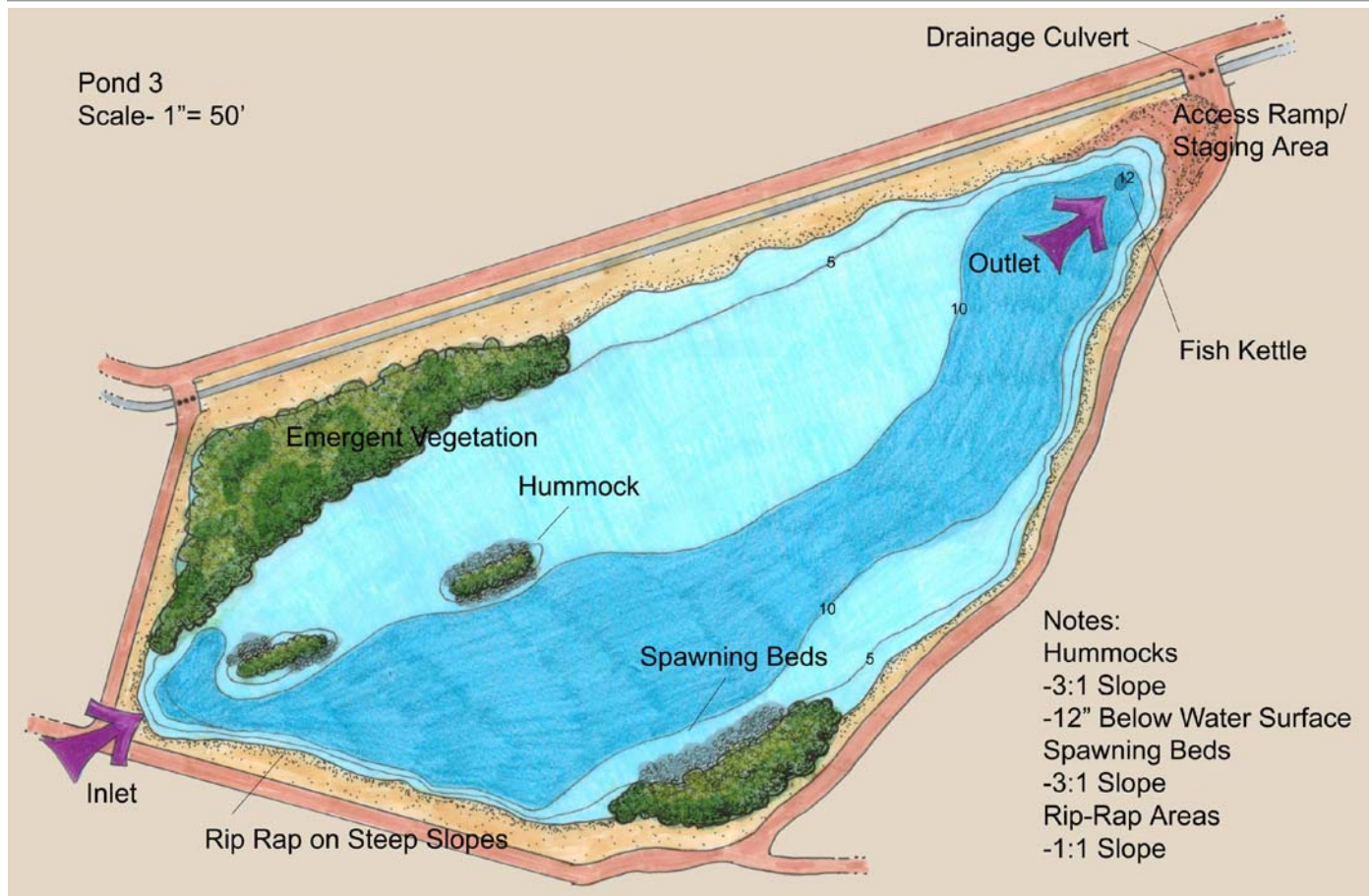
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate ranging from 1-3 inches.

Boat Ramp/Staging Area:

Develop launch area(s) on south end, east side.

Figure 7. Pond 3 - Plan View



Proposed Design - Pond 4

POND 4. LAYOUT DESCRIPTION (SEE FIGURE 8):

Pond 4 is based on the conceptual features suggested by Mueller and Carpenter (In Press), based on research at High Levee Pond. This pond is designed to closely replicate the physical features of the recommended design.

Water Delivery Infrastructure:

Place the inlet at the south end.

Place the outlet on the east side at the north end.

Size, Depth, and Contours:

Develop 10.2 acre pond.

Develop pond contours to represent the following depths:

- A. Twenty percent <5 feet with those depths between shore and the 10 foot contour.
- B. Thirty percent between 5 and 10 feet; with the majority of those depths within 15 feet of the edge.
- C. Fifty percent between 10 and 16+ feet.
- D. Maximum depth of 18 feet.

Hummocks/Vegetation:

Develop area(s) <5 feet deep for emergent vegetation.

Develop two hummocks west side near middle.

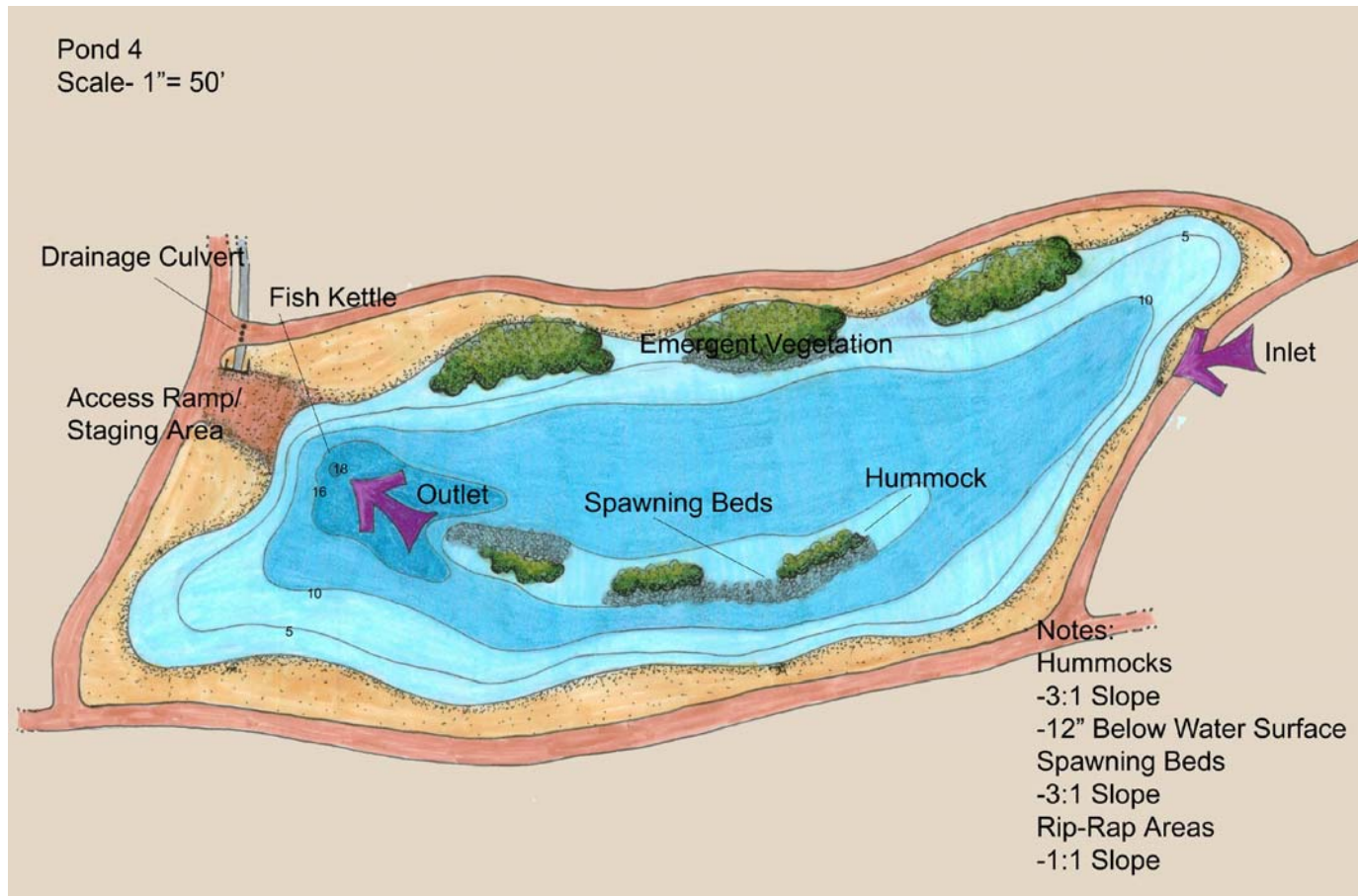
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate ranging from 1-3 inches.

Boat Ramp/Staging Area:

Develop launch area(s) on north end, east side.

Figure 8. Pond 4 - Plan View



Proposed Design - Pond 5

POND 5. LAYOUT DESCRIPTION (SEE FIGURE 9):

Water Delivery Infrastructure:

Place the inlet at the north end.

Place the outlet on the east side at the south end.

Size, Depth, and Contours:

Develop 17.2 acre pond.

Develop pond contours to represent the following depths:

- A. Ten percent <5 ft so that those depths are between shore and the 10-foot contour.
- B. Seventy percent between 5 and 10 feet; with the majority of those depths within 15 feet of the edge.
- C. Twenty percent between 10 and 12 feet.
- D. Maximum depth of 12 feet.

Hummocks/Vegetation:

No hummocks.

Develop area(s) <5 feet deep for emergent vegetation.

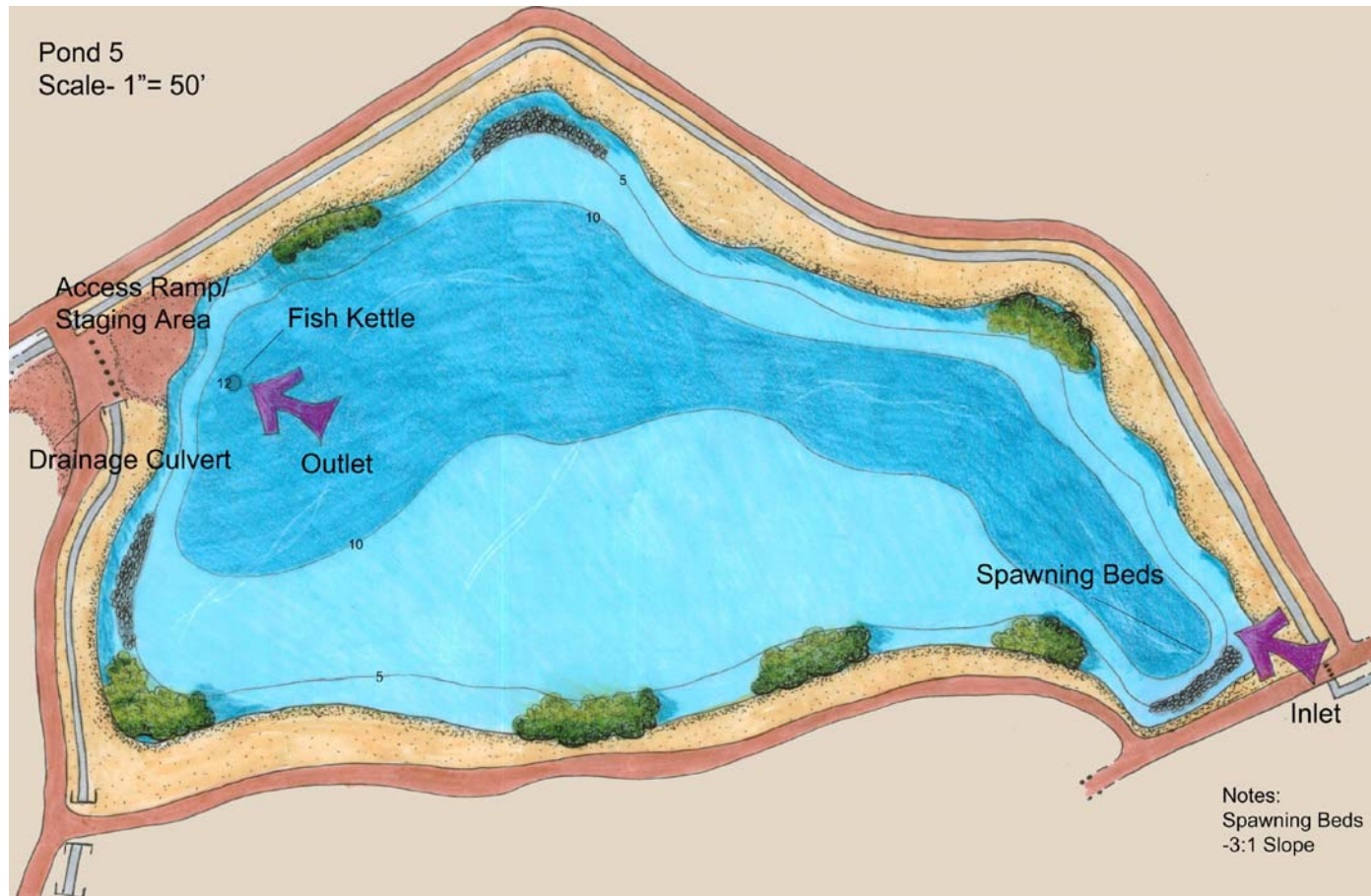
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate ranging from 1-3 inches.

Boat Ramp/Staging Area:

Develop launch area(s) on north end, east side.

Figure 9. Pond 5 - Plan View



Proposed Design – Pond 6

POND 6. LAYOUT DESCRIPTION (SEE FIGURE 10):

This pond will experimentally test the benefits of large numbers of hummocks on the resultant habitat quality of the pond. Eleven hummocks will be created, adjacent to deep water, to maximize shading during the hot summer months.

Water Delivery Infrastructure:

Place the inlet on the west side at the north end.

Place the outlet at the south end on east side.

Size, Depth, and Contours:

Develop 9.2 acre pond.

Develop pond contours to represent the following depths:

- A. Five percent <5 feet with those depths between shore and the 10-foot contour.
- B. Five percent between 5 and 10 feet; with the majority of those depths within 15 feet of the shore.
- C. Ninety percent between 10 and 12 feet.
- D. Maximum depth of 14 feet.

Hummocks/Vegetation:

Pond shoreline will be constructed to minimize vegetation establishment.

Develop a pond where hummocks are the dominant shade producing structures with surrounding depths of approximately 10 feet. Hummocks are to be oriented East-West to maximize shading during summer.

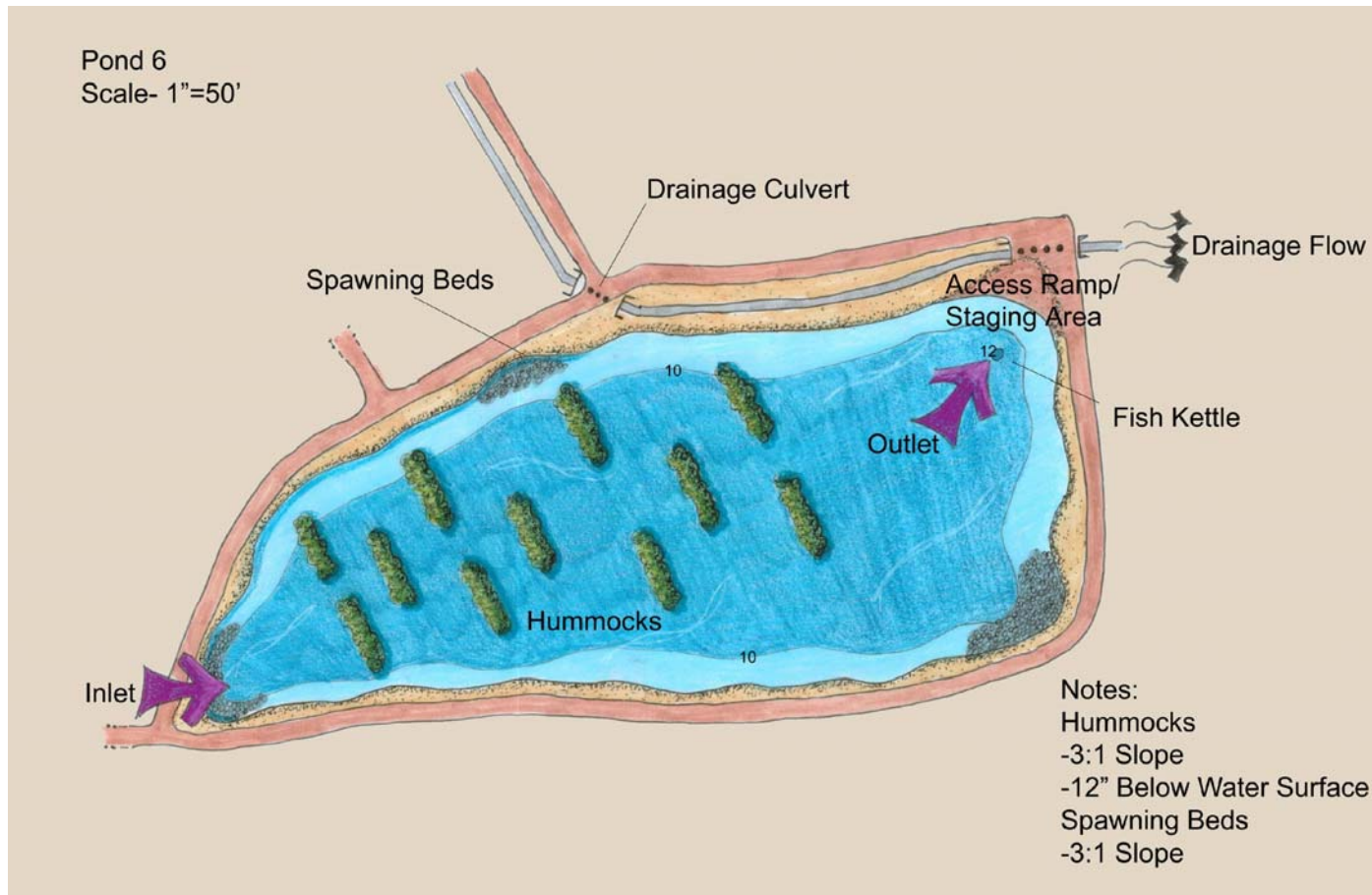
Spawning Beds:

Develop spawning area(s) in 5% of the pond in water <10 feet deep with substrate ranging from 1-3 inches.

Boat Ramp/Staging Area:

Develop launch area(s) on south end, east side.

Figure 10. Pond 6 – Plan View



Monitoring Program

There are two components of the monitoring program for the proposed design. They would include monitoring water quality and the fish populations.

Water Quality:

At a minimum, dissolved oxygen concentration, pH, specific conductivity, water temperature, depth, and Oxygen Reduction Potential (ORP) should be measured using a water quality multiprobe logger (i.e., such as a Hydrolab DataSonde®). Turbidity should be measured using a Secchi Disc or a Hydrolab® measuring in Nephelometric Turbidity Units (NTU's). This should be done at a minimum of three permanent sites within each pond to include: the inflow, mid-lake, and the outtake (greatest depth). Vertical profiles should be measured from surface to bottom in 0.5 or 1 meter intervals depending on the depth of the system. These parameters should be measured quarterly during the autumn, winter, and spring, and at least twice a month during the summer (or through any period when ambient temperatures exceed 30°C through the time they decrease below 30°C).

Fish Populations:

Fishery activities should include collection of larval fish during the appropriate time of the year. Collections should be made during the heat of the summer for a brief period (1 hour) in each pond to confirm the presence of larger fish and at least once during a cooler time of the year to determine overall fish health and population size. These collections would also document the occurrence of nonnative species triggering a renovation of a given pond. When a pond is compromised it should be renovated as efficiently as possible by draining the pond and removing the fish. Depending on the situation a total renovation could be achieved by using rotenone in the kettle or letting the pond dry after salvaging fish.

Use or Disposal of Excavated Material

Introduction:

Originally, terrestrial areas within the DU2 Ponds area were intended to be restored to cottonwood/willow forests. However, due to the high salinity of the soils, very few cottonwoods or willows survived. Some terrestrial areas surrounding the DU2 Ponds resemble salt flats, and are essentially devoid of vegetation. The electrical conductivity (EC) (a measure of soil salinity) of soil samples from these areas has ranged from 29 to 40 mmhos/cm. Generally, few cottonwoods or willows survive in soils with EC values greater than 3 mmhos/cm. Possibly, a layer of hypersaline soil developed above of the upper boundary of the water table, and past excavations extracted this hypersaline layer and spread it on the surface. Other terrestrial areas around the DU2 Ponds support a mix of tamarisk, willow, honey mesquite, screwbean mesquite, and phragmites (*Tamarix ramossissima*, *Salix goodingii*, *Prosopis glandulosa*, *Prosopis pubescens*, and *Phragmites spp.*, respectively). Most of the cottonwoods and willows planted in these areas died.

High soil salinity is a common problem throughout the LCR system, and agriculture has developed several techniques for rehabilitating saline soils. These techniques include leaching the salts downward by flooding and applying amendments, such as sulfuric acid, which chemically react with soil salts to form neutral compounds. These techniques have been applied to the terrestrial areas surrounding the DU2 Ponds, resulting in little increased success growing cottonwoods or willows. Anderson et al. (2004)⁸ expended large amounts of resources attempting to rehabilitate approximately 700 acres north of Yuma, Arizona with the goal of establishing cottonwoods and willows, and they eventually concluded the site's soils would never support a native cottonwood/willow forest despite their efforts. Practically speaking, there is a limit to the effectiveness of soil rehabilitation techniques. Enlargement of the DU2 Ponds will produce excess material, most likely of high salinity, and moving this material to other farm field units would compromise their ability to benefit wildlife. Moving this volume of material off the refuge could greatly increase construction costs. Therefore, as a solution we propose using a portion of this material in the construction of new roads and berms, the maintenance or upgrading of existing roads, and spreading the worst material along the fire break extending along the western edge of the triangle. Additionally, within the ponds features such as hummocks and spawning beds will be constructed with excavated product.

Vegetation Treatment

Vegetated areas surrounding the DU2 Ponds contain large amounts of exotic salt cedar (*Tamarix sp*) and other plant species, and vegetation would interfere with efficient construction. Furthermore, salt cedar is capable of resprouting from a very durable root collar following cutting or burning. Root plowing is one efficient method of removing vegetation, and the majority of the salt cedar roots. However, a number of root fragments typically break off, and are scattered by the machinery resulting in a number of resprouts. Consequently, follow-up herbicide treatments may be necessary. The operation also results in large piles of vegetation that need removed from the site. Burning the piles is an option, but another method is to chip and haul off the material. The

⁸ Anderson, B. W., R. E. Russell, and R. D. Ohmart. 2004. Riparian revegetation: An account of 2 decades of experience in the arid Southwest. Avvar Books. Blythe, California.

Use of Disposal of Excavated Product (Continued)

material can be used as mulch, but due to the large proportion of salt cedar, spreading the material in nearby units would not be desirable. We propose root plowing the entire terrestrial area of the DU2 Ponds, chipping the material using the Bureau of Land Management's chipper, and moving the material from the site.

Riprap, Gravel, Soil Sources

Steep sides are a desirable feature from an aquatic vegetation control and fish habitat standpoint, and are designed into a portion of each pond. Steep sides are intended to emulate the cut banks normally associated with river meandering. Soil will not normally maintain a steep angle for very long without slumping, therefore, riprap is necessary to maintain the stability of steeper sides. Additionally, native fish species have frequently used rip-rap at other locations, such as High Levee Pond, for cover during hot weather and for predator avoidance. Hummocks are also desirable features designed into each pond. The vegetation associated with hummocks is intended to provide important foraging habitat, shading, and cover for juvenile fish. Rip-rap is also useful for stabilizing hummocks, and ensuring their longevity. Providing spawning habitat is an objective for each pond, and gravel beds covering approximately 5 % of each ponds surface area will be constructed. Gravel is also necessary for road and boat ramp construction. Additionally, some soil will be used for the construction of roads and hummocks, and some of the less saline soil occurring on the site will be used for these purposes. It is assumed the areas containing vegetation are less saline than the areas with little or no vegetation. Rip-rap and gravel sources located at Laguna East will be used for the project.

Geology

During the construction of the DU2 Ponds in 1997-98 groundwater did not intrude upon the site, even though it is quite close to the Colorado River. This event was surprising, and it allowed land based excavation equipment to be used entirely. Also, some wells have been drilled to surprising depths without obtaining water, even though they were situated quite close to open water. Consequently, the groundwater hydrology in the area of the DU2 Ponds is not well understood, and several design and construction questions are difficult to answer with the current state of knowledge. For example, all of the ponds will be deepened, markedly in certain areas, and it is unknown if and where the groundwater table will be contacted. Therefore, it is difficult to currently know which types of construction equipment will be required, or if dewatering will be required during the construction. Additional questions concern the amount, if any, and quality of water that may infiltrate the ponds from the adjacent Colorado River. An exchange with the river could greatly influence the amount of water that will need to be pumped from groundwater wells. We propose to drill test wells throughout the area to determine the depth to groundwater, existence and extent of a clay lens, lateral movement of subterranean salt, determine the degree of connection to the river, and furnish soil samples.

Construction Cost Estimate

The total construction cost estimate (including mobilization), but not including unlisted items, contingencies, design, contracting, project management, and permitting cost is \$3,106,000.

It should be noted that it is not recommended that this cost estimate be used for budgeting or construction purposes. As the design is developed further, and at final spec, the design team will more accurately quantify the cost estimate for this project.

Any questions regarding this project should be directed towards:

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O&M Considerations and Cost Estimates

Rough Estimate of O&M Costs and Issues				
Item	How often	Assumptions	Cost/time	Annual Cost
Power for pumps at wells.	Continuous (75 HP for two wells; to keep DO and temperature within limits)	Rates from Wellton-Mohawk and would be able to negotiate.	Current cost: \$5,000-\$10,000/yr.	\$10,000 to \$20,000
Cost of pump and/or motor replacement. Also includes annual pump and motor upkeep to lengthen life.	One replacement every 25 years per pump. Annual cleaning and maintenance assumed at \$1500 per pump	Current well assumed to be able to last for life of project due to stainless steel screens. However, when geological data for the site becomes available this may change.	\$45,000 twice every 25 years.	\$3,000 for O&M every year plus \$90,000 every 25 years.
Monitoring of fish survival and health.	Hot months - twice/ month; Remainder of year -quarterly	Based on historical monitoring by USFWS; for new ponds the estimate is about 1/2 man year.	Assume 0.5 man years for first 20 years with possible back off later.	
Roads, berm and staging areas annual upkeep and maintenance.	As needed based on weather and also wear and tear from fish control.	Full redo every 10 years with possible resurfacing of staging areas more frequently.	\$7-8 per square yard.	
Spare parts for valves, pipe, and sampling equipment.	One spare valve each size, blind flange per size, gasket and bolt kit, pipe plug/repair, and hydrolab. Stock initially and then replace immediately after a part is used and removed from stock.	Government procurement system assumed and need for spare of strategic parts on site. Assumed storage area of 6 ft x 6 ft x 6 ft would suffice and that pipe could be procured in Yuma as needed.	\$1,500-\$2,000 per valve; \$200-\$300 per blind flange; valve kit - \$200; pipe plug/repair kit - \$300-\$600	\$1,000

Item	How often	Assumptions	Cost/time	Annual Cost
Renovate/poison contaminated or dead pond(s) (drain pond, poison/remove/destroy dead or contaminated fish), refill and then re-add fish.	Early on once per pond per 5 years with frequency decreasing to once per pond per 12 years after first 15 years of site life.	Rotenone at \$100/gal; need up to 10 gal/2.5 (a surface); 5-10 people for removal of fish or capture; assume minimal kettle surface area 2400 square feet per pond. This assumes that up to three ponds will need to be killed off in any one year.	\$100 in materials (Rotenone) plus labor (assumed 2 days of 5 to 10 people per renovation/poisoning for fish removal, etc.	\$100 materials plus 10 to 20 staff days of labor.
Security/signage.	Unknown.	Will be the responsibility of the Refuge.	Will be handled by refuge.	
Spare instrumentation - one Hydrolab; one spare each: DO, pH, EC, and temperature.	Hydrolab at least once/5 yrs; in line sensors - one each per year.	Storage costs by Refuge in their warehouse area and this allows for procurement issues.	\$3,000 - Hydrolab; Others - \$500+ \$200+ \$100+ \$100 = \$900-\$1,000	\$1,600
Boats and racks for each pond - one flat bottomed boat per pond with storage rack in staging area.	Replacement from age every 15 years; estimated cost \$2500.	Weathering, damage from wear and tear on riprap sides.	\$2,500 for 6 /12 years.	\$1,250